Title

Grindr Users Take More Risks, but Are More Open to Human Immunodeficiency Virus (HIV) Pre-exposure Prophylaxis: Could This Dating App Provide a Platform for HIV Prevention Outreach?

Journal

Clinical infectious diseases : an official publication of the Infectious Diseases Society of America, 71(7)

ISSN

1058-4838

Authors

Hoenigl, Martin
Little, Susan J
Grelotti, David
et al.

Publication Date

2020-10-01

DOI

10.1093/cid/ciz1093

Grindr™ Users Take more Risks, but are more Open to HIV Pre-Exposure Prophylaxis: Could this Dating App Provide Platform for HIV Prevention Outreach?

Running head: Grindr™ Use, sexual risk and PrEP

Martin Hoenigl, MD[1]; Susan J Little, MD[1]; David Grelotti, MD[2]; Britt Skaathun, PhD, MPH[1]; Gabriel A. Wagner, MD[1]; Nadir Weibel, PhD[3]; Jamila K. Stockman, PhD, MPH[1]; Davey M. Smith, MD[1,4]

[1] Division of Infectious Diseases and Global Public Health; University of California San Diego, La Jolla, California, United States

[2] Department of Psychiatry; University of California San Diego, La Jolla, California, United States

[3] Department of Computer Science and Engineering; University of California San Diego, La Jolla, California, United States

[4] Veterans Affairs Healthcare System, San Diego, California

Keywords

HIV risk, Dating App, Pre Exposure Prophylaxis, Substance Use, risk behavior.

Original data of this manuscript have been presented in part as oral presentation at ID Week 2019 in Washington DC, USA (Presentation Number 1961).

 # Corresponding author:

Martin Hoenigl, M.D., Ass. Prof.
Division of Infectious Diseases and Global Public Health,
University of California San Diego,
200 West Arbor Drive #8208
San Diego, CA 92103, United States of America
Phone: +1 6195435605
mhoenigl@ucsd.edu

Word count for manuscript: 2567

Word count for abstract: 250

Abstract

Background: Technology has changed the way men-who-have-sex-with-men (MSM) seek sex. Over 60% of MSM in the US use the internet and/or smartphone-based geospatial networking apps to find sex partners. We correlated use of the most popular app (Grindr™) with sexual risk and prevention behavior among MSM.

Methods: A nested cohort study was conducted between September 2018 and June 2019 among MSM receiving community-based HIV and STI screening in central San Diego. During the testing encounter, participants were surveyed for demographics, substance use, risk behavior (previous 3 months), HIV pre-exposure prophylaxis (PrEP) use, and Grindr™ usage. Participants who tested negative for HIV and who were not on PrEP were offered immediate PrEP.

Results: The study included 1,256 MSM, 1,087 of whom (86.5% percent) were not taking PrEP. Overall, 580/1,256 (46%) participants indicated that they used Grindr™ in the previous 7 days. Grindr™ users reported significantly higher risk behavior (greater number of male partners and condomless sex) and were more likely to test positive for chlamydia or gonorrhea (8.6% vs. 4.7% of non-users; $p=0.005$). Grindr™ users were also more likely to be on PrEP (18.7% vs. 8.7% of non-users; $p<0.001$) and had fewer newly diagnosed HIV infections (9 vs. 26 among non-users; $p=0.014$). Grindr™ users were also nearly twice as likely as non-users to initiate PrEP (24.6% vs. 14%; $p<0.001$).

Conclusion: Given the higher risk behavior and greater acceptance of PrEP among MSM who used Grindr™, Grindr™ may provide a useful platform to promote HIV and STI testing and increase PrEP uptake.

Introduction

Men-who-have-sex-with-men (MSM) represent the predominant risk group for HIV infection in the United States, and technology has changed the way MSM socialize and seek sex [1]. While social media networks mostly reflect real-world offline relationships, dating apps focus on meeting new sexual partners. Greater than 60% of MSM in the United States have used a dating app to meet a sexual partner in the past year [2-5]. Grindr™, a sophisticated geosocial networking app, is the most frequently used dating app in the United States [6].

The risk of HIV infection within MSM is not uniform [7]. Although though there are conflicting data regarding whether this translates into increased HIV acquisition, studies have indicated that MSM who use Grindr™ have a greater frequency of condomless anal intercourse (CAI), a higher incidence of sexually transmitted infections (STIs), and more sexual partners, [3, 8-11]. Meeting partners over Grindr™ or other geosocial networking apps may also facilitate serostatus disclosure, serosorting, negotiation regarding condom usage, discussion of sexual practices and user risk-assessment, therefore lowering overall risk [6, 12, 13]. Although Grindr may also serve as a forum to discuss HIV the use of pre-exposure prophylaxis (PrEP) [14] among Grindr™ users remains a under-explored topic [15].

We aimed to assess Grindr™ activity among MSM undergoing HIV and STI screening in San Diego, California. We then examined how Grindr™ use correlated with risk and prevention behavior, particularly focusing on PrEP use. We believe that this information can be used both to characterize HIV risk in this population and advance strategies to use geosocial networking apps as platforms to promote HIV prevention.

Material and Methods

Setting and Participants

The study was conducted between September 2018 and June 2019 and leveraged our "Good to Go" HIV and STI screening study for participant recruitment. Formerly named the Early Test, this community-based HIV and STI screening program provides free testing to adult MSM and transgender women participants who are willing to enroll and answer risk-related questions [16, 17]. The program utilizes a point-of-care rapid HIV test followed by routine reflex to individual donation HIV nucleic acid amplification testing in persons with negative rapid test results. STI screening assessments include syphilis (using the reverse screening algorithm [18]), Chlamydia spp. and Gonorrhea by nucleic acid amplification test of urine, pharyngeal and rectal swab specimens (Cepheid Xpert® CT/NG, Sunnydale, CA, USA). Data are collected by bilingual (Spanish and English) testing staff before each testing encounter including: demographics, sexual risk, number of sex partners, substance use (all in the previous 3 months) and PrEP use [17]. Participants who test positive for HIV or STI are offered immediate treatment at no cost. Those at substantial risk for HIV acquisition [19] who test negative for HIV and are not currently prescribed emtricitabine/tenofovir disoproxil fumarate (FTC/TDF) for PrEP are offered immediate PrEP.

Measures

Assessment of Grindr™ activity, HIV risk, and PrEP use

During their testing encounter, all MSM and transgender women participants presenting for the "Good to Go" were surveyed for Grindr™ usage (i.e. opening Grindr™ on their mobile device during the previous 7 days), demographics, substance use and HIV risk behavior during the previous 3 months, and PrEP use (i.e. any PrEP intake during last 14

days), and. Participants with iPhones were instructed on how to assess Grindr™ on screen activity (i.e., time on screen during last 7 days; automatically recorded by phones) on their phones, and provided that data via the questionnaire (Figure 1).

Classification of risk behavior

This study utilized the San Diego Early Test Score (SDET) score as a measure of risk behavior for the target MSM population [7, 20]. The score focuses on current risk for HIV acquisition among MSM: condomless receptive anal intercourse (CRAI) with an HIV-positive MSM, combination of CRAI plus number of male partners, and recent bacterial STI [7, 20]. In the derivation and validation cohorts used to derive the score, symptoms and risk behaviors were both assessed for the 12 months prior to the testing encounter. To take into account the 3-month risk reporting period in the "Good to Go", we created an "adjusted SDET" by adjusting 2 original variables "the combination of CRAI plus ≥5 male partners in the previous 12 months" to "the combination of CRAI plus ≥2 male partners in the previous 3 months", and "≥10 male partners in the previous 12 months" to "≥5 male partners in the previous 3 months", as described elsewhere [21]. We also combined self-reported recent STI with new STI diagnosis at the testing encounter into one variable that informed SDET calculation. While the score focused on sexual risks, changes in sexual behavior associated with substance use were also captured [22].

PrEP initiation

All participants with HIV risk behavior who tested negative for HIV and reported no PrEP use during the last 14 days were offered immediate PrEP beginning in November 2018. For these participants, the first 30-days of PrEP were provided via the "Good to Go" study.

Statistical analysis

All statistical analysis was conducted using SPSS 25 (SPSS Inc, Chicago, Illinois). Demographics, PrEP use, PrEP initiation, substance use, risk behaviors, adjusted SDET scores, and HIV/STI diagnoses were compared between participants who reported recent Grindr™ use versus those who did not using Fisher's exact test/Chi-square test for categorical variables and Students T-Test/Mann Whitney-U test for continuous variables. Univariate and multivariable logistic regression analyses assessed predictors of initiating PrEP after the testing encounter. Variables with a p-value <0.2 in univariate analysis were included in the multivariable model. Variables in the final model were selected with a stepwise forward procedure. Model discrimination was assessed by the goodness-of-fit Hosmer-Lemeshow statistics. Odds ratios (ORs) and adjusted odds ratios (aOR) including 95% confidence intervals (CIs) were calculated and a p-value of <0·05 was considered statistically significant. The study was approved by the University of California, San Diego institutional review board (IRB) and written informed consent was obtained from all participants.

Results

Survey data were collected from 1256 consecutive MSM and transgender females who participated in the "Good to Go" between September 2018 and June 2019. Median age was 32 years (IQR 27-44 years; range 18-78); 421 (33.5%) reported Hispanic ethnicity, 532 were non-Hispanic white (42.3%), 140 non-Hispanic Asian (11.1%), 80 non-Hispanic black (6.4%), and 83 (6.6%) non-Hispanic mixed or other races. The majority identified as male (n=1237; 98.5%), with smaller proportions identifying as trans female (n=11; 0.9%), or other non-binary identity (n=8; 0.6%). Overall 1017 participants (81%) reported their sexual orientation as gay, 187 (14.9%) as bisexual, 21 (1.7%) heterosexual, and 31 another sexual orientation (2.5%), with all 1256 participants reporting sex with men.

Grindr™ Use, Risk Behavior, and Testing Outcomes

A total of 580/1256 (46%) participants (including 571 men, 5 transwomen and 4 who identified as other gender) indicated that they had opened Grindr™ during the previous 7 days. Demographic data, risk behavior, and stimulant substance use in those with and without recent Grindr™ use are displayed in Table1.

Grindr™ users had higher adjusted SDET risk behavior scores than those not using Grindr™ (median SDET 2, IQR 0-5; versus median SDET 0, IQR 0-3; $p<0.001$), driven mostly by having more male sexual partners (median male sex partners in last 3 months 4, IQR 2-7 versus median 2, IQR 1-4; $p<0.001$). There were also tendencies towards Grindr™ users more frequently reporting CRAI [297/580 (51.2%) vs 310/676 (45.9%); p=0.059], or recent illicit stimulant use [113/580 (19.5%) vs. 105/676 (15.5%); p=0.065], while there was no difference in self-report of recent bacterial STI diagnosis (3.4% of study population; p=0.5).

Grindr™ users were more likely to test positive for chlamydia or gonorrhea at their testing encounter [50/556 (8.6%) tested positive for one or both] versus 32/676 (4.7%) of Grindr™ non-users (p=0.005). Grindr™ users were overall less likely to test positive for HIV [9/580 (1.6%) vs 26/676 (3.8%) of Grindr™ non-users tested positive; p=0.014], whereas no difference was observed for Syphilis and HCV diagnoses (Table 1).

Grindr™ Use and PrEP

Of 1256 participants, 1087 (86.5%) reported that they were not taking PrEP (defined as no PrEP intake within last 14 days). Grindr™ users were more likely to be taking PrEP than those Grindr™ non-users [107/580 (18.4%) among Grindr™ users versus 59/676 (8.7%) non-users; p<0.001]. Overall, 472/1087 (43.4%) of participants who were not taking PrEP reported recent Grindr™ use. Among those participants who were not taking PrEP, Grindr™ users had significantly higher sexual risk behavior [SDET median 2 (IQR 0-5) among Grindr users vs. median 0 (IQR 0-3) among non-users, p<0.001; male sex partners median 4 (IQR 2-6) vs. median 2 (IQR 1-4); p<0.001], but no difference was observed regarding CRAI and recent illicit stimulant use.

From November 2018 when immediate PrEP was made available at our community-based program, PrEP-eligible Grindr™ users were nearly twice as likely to start PrEP after the testing encounter compared to non-users (100/406, 24.6% of Grindr™ users started PrEP versus 72/514, 14.0% of non- users; p<0.001). In the multivariable logistic regression analysis, recent Grindr™ use (OR 1.61), adjusted SDET score (OR 1.20 per score point), younger age (OR 0.96 per year), and diagnosis of chlamydia or gonorrhea infection at "Good to Go" testing encounter (OR 2.00) were significant and independent predictors of PrEP initiation (Table 2).

Grindr On-Screen activity

Of 580 MSM who indicated recent Grindr™ use, 376 (64.8%) were iPhone™ users, of which 340 had their iPhone™ with them at the testing encounter. This allowed us to objectively assess screen time on Grindr™. Median on screen activity during the previous 7 days was significantly higher in those who reported PrEP use within the last 14 days (60/340; 18%), versus those who did not [280/340 (82%); median on screen time 244 minutes over last 7 days (IQR 75-534) in those with PrEP vs. median 142 (IQR 47-360) in those without; p=0.017].

Overall, there was no significant correlation between adjusted SDET scores and Grindr™ on screen activity among those not on PrEP (p>0.5); however, those at highest risk for HIV (SDET 8 or higher), had a trend towards being the highest Grindr™ utilizers [i.e. >90th percentile of time on screen corresponding to > 660 minutes during the last 7 days; 5/25 (25%) of those with highest sexual risk vs. 21/255 (8.2%) of those with lower sexual risk; p=0.053].

Discussion

Over the last decade, MSM have increasingly utilized geosocial dating apps to find sex partners [23]. This study assessed use of the most popular app in 1,256 MSM and transgender women undergoing community-based HIV and STI screening in San Diego. In our sample, those who use Grindr reported behaviors that placed them at greater risk for HIV. Although Grindr™ users were more likely than non-users to be taking PrEP, more than 8 in 10 were not using FTC/TDF at the time of their testing encounter. Grindr users were more likely to initiate PrEP after the testing encounter, indicating that Grindr™ could serve as a platform for educating those at high risk for HIV about the benefits of PrEP and linking users to programs that offer PrEP.

Consistent with previous reports, Grindr™ users in our study had higher sexual risk and were more likely to test positive for Chlamydia and Gonorrhea infections [4, 10, 11]. Additionally, we found that Grindr users were more likely to have taken PrEP within two weeks before the testing encounter (18.7% among Grindr™ users versus 8.7% among non-users) and were overall – possibly as a consequence - less likely to test positive for HIV (9 new diagnoses among Grindr™ users versus 26 new diagnoses among non- users). Importantly, the majority of Grindr™ users (81.3%) were not on PrEP, despite having significantly higher sexual risk behavior compared to non-users. After the testing encounter, Grindr™ users were more likely to start PrEP through our program (24.6% of Grindr™ users started PrEP versus 14% of non-users), and Grindr™ use remained an independent predictor of PrEP initiation in multivariate analysis (other predictors higher sexual risk, younger age, and Chlamydia/Gonorrhea diagnosis). One explanation for the comparatively high rate of PrEP initiation among Grindr users despite low current PrEP usage, is that PrEP has simply not been previously made readily available to them before – a linkage that may have been enhanced by HIV testing and counseling, review of HIV risks, or a positive STI screen.

This study also introduced an objective measure of Grindr™ on-screen activity, allowing quantification of active Grindr™ use in minutes. Among Grindr™ users, those with the highest sexual risk behavior were found to be actively using Grindr™ significantly more compared to those with lower sexual risk behavior. Characterization of Grindr™ on-screen activity may be a useful tool for identifying MSM and transgender women who may benefit most from PrEP and more frequent STI testing.

Given the higher risk behavior and greater acceptance of PrEP among Grindr™ users, PrEP promotional messages and linkages to care on the Grindr™ platform could enhance PrEP uptake, as well as increase testing for HIV and STIs. The surge of dating apps and their association with high risk sex, offers unique opportunities for broad delivery of prevention messages [11, 24]. Grindr™ may provide a real opportunity to reach those at risk and substantially increase PrEP awareness and uptake. However, how to effectively deliver these messages on Grindr™ needs to be further evaluated. Grindr™ commercially offers banner ads, which can convey an HIV prevention message allowing messages to be targeted toward specific regions with messages that are tailored toward specific PrEP providers. Previous studies evaluated Grindr™ ads for recruitment for HIV prevention interventions [25-29], and found that Grindr™ ads can help recruitment for HIV prevention efforts, particularly among older MSM. However, generic banner ads may be less effective at reaching hidden-populations [27, 29-31], and ad costs are generally predicted to increase [24, 27, 30]. Banners and advertisements generally do not harness the social dimension of geospatial networking apps. Behavior and behavior change diffuse through social networks of close ties and are affected by individuals' perceptions of what their network members do [32-34]. Therefore, a more personalized delivery of prevention messages, e.g. via advertisement on profile pictures of selected opinion leaders, may be more effective than banner ads for delivering prevention messages to Grindr™ users. Indeed, network-based recruitment have proven very effective at

locating people with undiagnosed HIV infections [35, 36]. Each of these approaches warrant further investigation.

There are important limitations to this study. The study took place at a single community-based testing site thus our findings might not be generalizable to other locations and populations. Furthermore, slight modifications of the previously validated SDET risk score were necessary to fit our available data and analyses. We also did not collect data on the usage of other geospatial networking app platforms (such as Scruff, Hornet, etc.) which may be used by persons who have a higher risk profile or had a similar risk profile and biased the results of comparisons between Grindr users and non-users toward the null. Nevertheless, with Grindr being the most popular app, it is likely that users of these other apps were also Grindr™ users. Finally, our sub analysis on on-screen activity was limited to iPhone users.

In conclusion, Grindr™ users took more sexual risks and had more partners than those who did not use the geosociall networking app, but they also were more likely than non-users to take PrEP or initiate PrEP. These findings suggest that Grindr ™ could be an effective vehicle for reaching people at risk for contracting HIV or other STIs, to encourage HIV and STI testing, and to engage them to start PrEP.

Conflicts of interest

Dr. Hoenigl received grant funding from Gilead Sciences, Inc.

Dr. Little received grant funding from Gilead Sciences, Inc.

Dr. Smith: received grant funding from Pfizer/ViiV, and has consulted for AIDS Healthcare Foundation

Dr. Grelotti consulted for Greenwich Biosciences, Inc.

Other authors: no conflicts

Funding

This work was primarily supported by the PIRC grant from National Institutes of Health (AI106039). In addition, the work was partially supported by other grants from the National Institutes of Health (AAI064086, MH081482, MH113477, AI 036214, DA023606, MH062512, and AI106039).

Table 1: Demographic Data and Risk Behavior, and Substance Use Characteristics as well as Testing Outcomes of participants who did and did not report recent Grindr™ use.

Variables: N(%) if not stated otherwise	Grindr™ users* (n=580)	Grindr™ non-users* (n=676)	P-value
Gender:			0.976
Male	571 (98%)	666 (99%)	
Transgender female	5 (1%)	6 (1%)	
Other	4 (1%)	4 (1%)	
Age, years; mean (SD)	35 (12)	38 (13)	<0.001
Race			0.502
White	371 (64%)	420 (62%)	
Hispanic Ethnicity:	200 (34%)	221 (33%)	0.555
Adjusted SDET Score (median, IQR)	2 (0-5)	0 (0-3)	<0.001
Male Sex Partners (recent 3 months; median, IQR)	4 (2-7)	2 (1-4)	<0.001
Number reporting Condomless Anal Intercourse (recent 3 months)	297 (51%)	310 (46%)	0.059
Stimulant Substance Use #	113 (19%)	105 (16%)	0.065
Self-reported PrEP intake within last 14 days	107 (18%)	59 (9%)	<0.001
Self-reported recent bacterial STI Diagnosis (recent 3 months)	22 (3.8%)	21 (3.1%)	0.505
Testing positive for HIV	9 (1.8%)	26 (3.8%)	0.014
Testing positive for Chlamydia or Gonorrhea	50 (8.6%)	32 (4.7%)	0.005
Testing positive for Syphilis	13 (2.2%)	11 (1.6%)	0.428
Testing positive for HCV	0	4 (0.6%)	0.129

* Defined as within last 7 days.

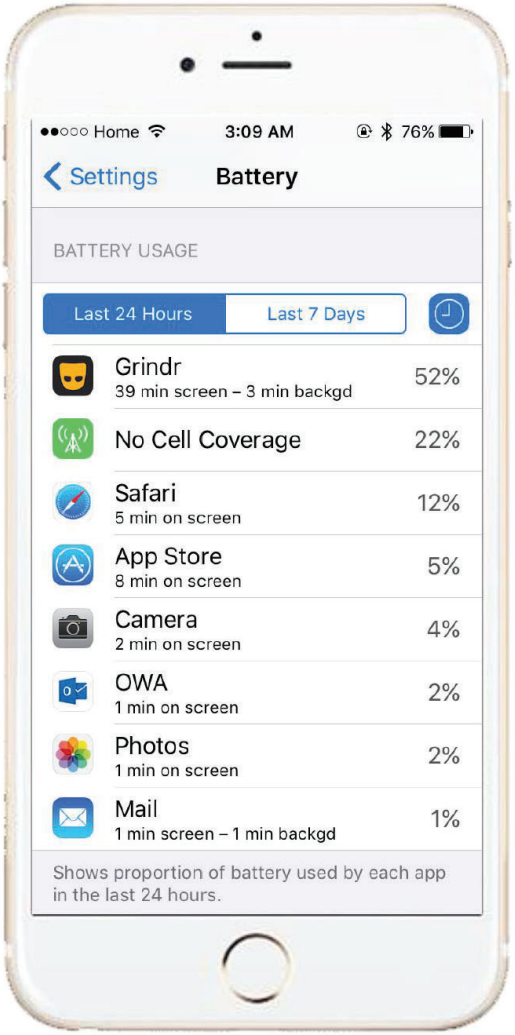
1 # Stimulants: methamphetamine, cocaine, GHB, poppers, ecstasy, ketamine.

2

Table 2 Univariate and multivariable binary Logistic Regression Models for predicting initiation of PrEP among participants offered PrEP through the total test (n=920 of which 172 initiated PrEP).

Model	OR	95% CI	p value	aOR	95% CI	p value
	Univariate Model			**Multivariable Model***		
Recent Grindr™ use	2.006	1.433 – 2.808	<0.001	1.611	1.129 – 2.299	0.009
Adjusted SDET score (per point)	1.250	1.174 – 1.331	<0.001	1.196	1.116– 1.282	<0.001
Age (per year)	0.960	0.944 – 0.976	<0.001	0.964	0.948 – 0.981	<0.001
Stimulant Substance Use last 3 months	1.634	1.090 – 2.450	0.017	n.s.		
Diagnosis of Chlamydia or Gonorrhoea infection at Testing encounter	3.751	2.139 – 6.576	<0.001	1.996	1.076 – 3.701	0.028
Hispanic Ethnicity	1.381	0.983 – 1.940	0.063	n.s.		
* $x^2 = 6.077$; $p = 0.639$ Hosmer–Lemeshow; Forward Wald Binary Logistic Regression Abbreviation: OR=odds ratio; aOR=adjusted odds ratio						

Figure 1: I-phone system app that monitors Grindr™ on screen activity.



References

1. Martin TCS, Chaillon A, Graves SK, et al. Genetic network analysis to assess the risk of HIV transmission among MSM seeking partners on the Internet. Clinical infectious diseases : an official publication of the Infectious Diseases Society of America **2019**.
2. Phillips G, 2nd, Magnus M, Kuo I, et al. Use of geosocial networking (GSN) mobile phone applications to find men for sex by men who have sex with men (MSM) in Washington, DC. AIDS and behavior **2014**; 18(9): 1630-7.
3. Beymer MR, Weiss RE, Bolan RK, et al. Sex on demand: geosocial networking phone apps and risk of sexually transmitted infections among a cross-sectional sample of men who have sex with men in Los Angeles County. Sexually transmitted infections **2014**; 90(7): 567-72.
4. Winetrobe H, Rice E, Bauermeister J, Petering R, Holloway IW. Associations of unprotected anal intercourse with Grindr-met partners among Grindr-using young men who have sex with men in Los Angeles. AIDS Care **2014**; 26(10): 1303-8.
5. Lehmiller JJ, Ioerger M. Social networking smartphone applications and sexual health outcomes among men who have sex with men. PloS one **2014**; 9(1): e86603.
6. Rendina HJ, Jimenez RH, Grov C, Ventuneac A, Parsons JT. Patterns of lifetime and recent HIV testing among men who have sex with men in New York City who use Grindr. AIDS and behavior **2014**; 18(1): 41-9.
7. Hoenigl M, Weibel N, Mehta SR, et al. Development and validation of the San Diego Early Test Score to predict acute and early HIV infection risk in men who have sex with men. Clinical infectious diseases : an official publication of the Infectious Diseases Society of America **2015**; 61(3): 468-75.
8. Eaton LA, Maksut JL, Gamarel KE, Siembida EJ, Driffin DD, Baldwin R. Online Sex Partner Meeting Venues as a Risk Factor for Testing HIV Positive Among a Community-Based Sample of Black Men Who Have Sex With Men. Sexually Transmitted Diseases **2016**; 43(6).
9. Mustanski BS. Are sexual partners met online associated with HIV/STI risk behaviours? Retrospective and daily diary data in conflict. AIDS Care **2007**; 19(6): 822-7.
10. Chan PA, Crowley C, Rose JS, et al. A network analysis of sexually transmitted diseases and online hookup sites among men who have sex with men. Sexually transmitted diseases **2018**.
11. Landovitz RJ, Tseng CH, Weissman M, et al. Epidemiology, sexual risk behavior, and HIV prevention practices of men who have sex with men using GRINDR in Los Angeles, California. Journal of urban health : bulletin of the New York Academy of Medicine **2013**; 90(4): 729-39.
12. Paz-Bailey G, Hoots BE, Xia M, et al. Trends in Internet Use Among Men Who Have Sex With Men in the United States. Journal of acquired immune deficiency syndromes (1999) **2017**; 75 Suppl 3(Suppl 3): S288-S95.
13. Cruess DG, Burnham KE, Finitsis DJ, et al. Online Partner Seeking and Sexual Risk Among HIV+ Gay and Bisexual Men: A Dialectical Perspective. Archives of Sexual Behavior **2017**; 46(4): 1079-87.
14. Hoenigl M, Hassan A, Moore DJ, et al. Predictors of Long Term HIV Pre Exposure Prophylaxis Adherence after Study Participation in Men who have Sex with Men. Journal of acquired immune deficiency syndromes (1999) **2019**.
15. Holloway IW, Dougherty R, Gildner J, et al. Brief Report: PrEP Uptake, Adherence, and Discontinuation Among California YMSM Using Geosocial Networking Applications. Journal of acquired immune deficiency syndromes (1999) **2017**; 74(1): 15-20.
16. Hoenigl M, Graff-Zivin J, Little SJ. Costs per Diagnosis of Acute HIV Infection in Community-based Screening Strategies: A Comparative Analysis of Four Screening Algorithms. Clinical infectious diseases : an official publication of the Infectious Diseases Society of America **2016**; 62(4): 501-11.

17. Hoenigl M, Anderson CM, Green N, Mehta SR, Smith DM, Little SJ. Repeat HIV-testing is associated with an increase in behavioral risk among men who have sex with men: a cohort study. BMC medicine **2015**; 13(1): 218-015-0458-5.
18. Discordant results from reverse sequence syphilis screening--five laboratories, United States, 2006-2010. MMWR Morbidity and mortality weekly report **2011**; 60(5): 133-7.
19. Prevention CfDCa. US Public Health Service: Preexposure prophylaxis for the prevention of HIV infection in the United States—2017 Update: a clinical practice guideline., **2018**.
20. Dijkstra M, Lin TC, de Bree GJ, Hoenigl M, Schim van der Loeff MF. Validation of the San Diego Early Test Score for early HIV infection among Amsterdam men who have sex with men. Clinical infectious diseases : an official publication of the Infectious Diseases Society of America **2019**.
21. Cohen SE, Vittinghoff E, Philip SS, et al. Sexual Risk Behaviors and Sexually Transmitted Infections Among MSM participating in the US PrEP Demo Project. World HIV & STD Congress, 2015 Brisbane, Australia **2015**.
22. Hoenigl M, Chaillon A, Moore DJ, Morris SR, Smith DM, Little SJ. Clear Links Between Starting Methamphetamine and Increasing Sexual Risk Behavior: A Cohort Study Among Men Who Have Sex With Men. Journal of acquired immune deficiency syndromes (1999) **2016**; 71(5): 551-7.
23. Grov C, Breslow AS, Newcomb ME, Rosenberger JG, Bauermeister JA. Gay and bisexual men's use of the Internet: research from the 1990s through 2013. Journal of sex research **2014**; 51(4): 390-409.
24. Holloway IW, Rice E, Gibbs J, Winetrobe H, Dunlap S, Rhoades H. Acceptability of smartphone application-based HIV prevention among young men who have sex with men. AIDS and behavior **2014**; 18(2): 285-96.
25. Alarcon Gutierrez M, Fernandez Quevedo M, Martin Valle S, et al. Acceptability and effectiveness of using mobile applications to promote HIV and other STI testing among men who have sex with men in Barcelona, Spain. Sexually transmitted infections **2018**; 94(6): 443-8.
26. Burrell ER, Pines HA, Robbie E, et al. Use of the location-based social networking application GRINDR as a recruitment tool in rectal microbicide development research. AIDS and behavior **2012**; 16(7): 1816-20.
27. Huang E, Marlin RW, Young SD, Medline A, Klausner JD. Using Grindr, a Smartphone Social-Networking Application, to Increase HIV Self-Testing Among Black and Latino Men Who Have Sex With Men in Los Angeles, 2014. AIDS Education and Prevention : Official Publication of the International Society for AIDS Education **2016**; 28(4): 341-50.
28. Sun CJ, Stowers J, Miller C, Bachmann LH, Rhodes SD. Acceptability and feasibility of using established geosocial and sexual networking mobile applications to promote HIV and STD testing among men who have sex with men. AIDS and behavior **2015**; 19(3): 543-52.
29. Rosengren AL, Huang E, Daniels J, Young SD, Marlin RW, Klausner JD. Feasibility of using Grindr(TM) to distribute HIV self-test kits to men who have sex with men in Los Angeles, California. Sexual health **2016**.
30. Badal HJ, Stryker JE, DeLuca N, Purcell DW. Swipe Right: Dating Website and App Use Among Men Who Have Sex With Men. AIDS and behavior **2017**.
31. Lampkin D, Crawley A, Lopez TP, Mejia CM, Yuen W, Levy V. Reaching Suburban Men Who Have Sex With Men for STD and HIV Services Through Online Social Networking Outreach: A Public Health Approach. Journal of acquired immune deficiency syndromes (1999) **2016**; 72(1): 73-8.
32. Schneider JA, Zhou AN, Laumann EO. A new HIV prevention network approach: sociometric peer change agent selection. Social science & medicine (1982) **2015**; 125: 192-202.
33. Laumann EO, Gagnon JH, Michael RT, Michaels S. The Social Organization of Sexuality: Sexual Practices in the United States. Chicago, IL: University of Chicago Press, **2000**.

34. Laumann EO. Network analysis in large social systems: Some theoretical and methodological problems. New York: Academic Press, **1979**.
35. Smyrnov P, Williams LD, Korobchuk A, et al. Risk network approaches to locating undiagnosed HIV cases in Odessa, Ukraine. Journal of the International AIDS Society **2018**; 21(1): 10.1002/jia2.25040.
36. Nikolopoulos GK, Pavlitina E, Muth SQ, et al. A network intervention that locates and intervenes with recently HIV-infected persons: The Transmission Reduction Intervention Project (TRIP). Scientific reports **2016**; 6: 38100.